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DATELINE LOS ALAMOS

U.S. DEPARTMENT OF ENERGY
UNIVERSITY OF CALIFORNIA

TEST SITE SCIENCE

SPIN-OFFS SERVE SOCIETY

The Nevada Test Site celebrates its fiftieth anniversary this month. To scientists at Los Alamos, nuclear testing at NTS was an indispensable tool.

On Jan. 27, 1951, the first atmospheric test in Nevada was a Los Alamos device detonated at 1,060 feet above the surface of Frenchman Flat. The last test at NTS, Sept. 23, 1992, was also a Los Alamos test.

Nine hundred twenty-eight tests had been conducted in Nevada. Los Alamos conducted 462 of these tests. The weapons laboratories and the Defense Department were not the only beneficiaries of test site science and engineering advances. There were civilian benefits as well.

There were 27 Plowshare tests—a series of tests to explore the feasibility of using nuclear explosions for excavation, natural gas exploration and other peaceful uses. Most memorable was the excavation experiment named Sedan conducted on July 6, 1962. Sedan was a 104-kiloton nuclear device detonated 635 feet underground. The project was designed to test the nuclear abilities for possibly developing earth-moving technologies. The explosion displaced about 12 million tons of earth, creating a crater 1,280 feet in diameter and 320 feet deep.

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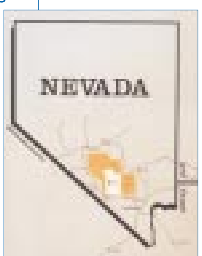
The Nevada Test Site is a massive outdoor laboratory and national experimental center. Larger than the state of Rhode Island, it is 1,350 square miles, making this one of the largest secured areas in the United States. The remote site is surrounded by thousands of additional acres of land withdrawn from the public domain for use as a protected wildlife range and for a military gunnery range, creating an unpopulated land area comprising some 5,470 square miles.



NASA's astronauts used the NTS to prepare for a moon landing. Because the craters had features similar to the topography of moon craters, astronauts from Apollo 14, 16 and 17 missions trained at the test site. The test site training was only a small part of the astronaut training, but proved to be a memorable one. Astronaut Harrison Schmitt referred to the similarities of a test site crater when describing one on the moon.

In the mid-1950s, Los Alamos and NASA scientists initiated a nuclear rocket program called Project Rover at the test site. The Rover Project successfully demonstrated that a nuclear reactor could be used to heat liquid hydrogen for spacecraft propulsion. The Kiwi, Phoebus, Peewee and Nuclear Furnace series were developed and tested to understand the basics of nuclear rocket reactor technology. Based on the success of this program, scientists began to design a nuclear rocket. In 1969, plans for human exploration of Mars were abandoned and the Rover Program was canceled in the early 1970s.

Nuclear weapons tests were very complex. During the weapon's high-explosive phase, materials are subjected to extreme pressures and temperatures. When the fissionable material in the weapon reaches a critical mass, it causes an incredible generation and release of energy.

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Under these conditions, even the heaviest atoms are almost completely ionized. Neutron and gamma radiation is so intense that the higher-order nuclear processes become common. Research knowledge of such extreme energy-density conditions has been gained through a combination of theoretical calculations and experiments conducted in nuclear tests.

When testing went underground or in tunnels, test site science became more challenging. A wide range of scientific disciplines was necessary. Geologists, geophysicists, physicists, theoretical physicists, mathematicians, statisticians, chemists, electrical engineers, just to name a few, were some of the many types of scientists represented to safely and successfully conduct a test.

One of the benefits coming out of underground testing is that scientists developed new computer codes and measuring techniques. A specific diagnostic technique called CORRTEX, for Continuous Reflectometry for Radius versus Time Experiments, measured how fast an underground blast's supersonic shock wave moved through the layers of earth. CORRTEX remains the most accurate nonintrusive technique the United States has found to determine the yield of nuclear blasts.

Several very significant technologies have spun off to benefit society. When a nuclear device was tested, a large pulse of electromagnetic energy was released. Basically the pulse is a short, but very strong radio wave that is propagated in a tunnel or a vertical emplacement test. The most important benefit to

Numerous craters at the Nevada Test Site provided a moonscape-like terrain for astronaut training.

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people beyond the gates of the test site was the understanding of the pulse from researchers who studied the wave and understood its properties. This led to the development of a radio communication system for use in mines. In mines, radio waves don't travel easily. By understanding the propagation and behavior of electromagnetic waves, scientists have developed a radio for use in mines — a radio system that works even during emergencies such as mine collapses.

Another spinoff of EMP test site knowledge has led to the development of a device to detect underground facilities, such as pipes, infrastructure, even archeological sites. The use of this device helped law enforcement officials detect the Otay drug trafficking tunnel that existed under the border of California and Mexico. Currently, the technology is being used to develop a small device that will detect non-metallic land mines.

Extensive cabling was required to accurately record all the data from nuclear explosions. The development of a radiation-resistant fiber optic cable was a direct result of NTS scientists' quest for efficiency.

Technicians and researchers relied on millions and millions of coaxial cables to relay data to detectors. Scientists tried to use fiber-optic cables because they carry much more data. One fiber-optic cable could eliminate a bundle of coax cables. But fiber-optic cables could not withstand the large dose of neutron and gamma rays from the nuclear blast.

The fiber-optic cable stopped working but would recover within microseconds — much too slow to record data from the nuclear explosion. Working with manufacturers, researchers helped develop a fiber-optic cable that could better withstand the doses of radiation and had a quicker recovery time. The research involved nuclear physics, solid-state physics andoptics. It was a theoretician's delight. Now these cables are used for diagnostics in the nuclear power industry.

After more than 30 years of nuclear testing, researchers developed high-speed cameras that were continuously redesigned and modified as new technology became available. Two key requirements were needed for cameras at the test site. The first was a fast-readout capability for the cameras to accomplish readout and telemetry of the images uphole before the destruction of the cameras by the shock-waves associated with the detonation. All of this occurs within a few milliseconds. The second need was a fast-shuttering capability to allow the capture or freezing of the nuclear phenomena associated with the device physics, which occurred in the nanosecond range.

The first cameras had readout speeds in the range of 16-32 milliseconds per frame and shutter speeds capable of hundreds of nanoseconds. Today's newest cameras can read out in 250 to 500 microseconds with 16-32 milliseconds per frame and the shutter speed is now 100 to 200 picoseconds, or about 1,000 times faster.

The improvements are a result of both Los Alamos-sponsored research and development and industry improvements to the camera components. The new cameras represent the world's fastest cameras for continuous framing by a single camera and also the fastest camera for "burst" mode framing, using the significantly faster shutter speeds to time phase several individual cameras.

Since the test ban, the fast shutter components of the cameras have been used for dynamic proton radiography to image shock propagation characteristics of materials in support of the Lab's stockpile stewardship program (see Dateline Followup).

Using pulsed lasers and capitalizing on the camera's shuttering capability, the cameras have been used for various applications to range images from strategic locations or distances for target identification and for discrimination of atmospheric clutter such as clouds or battlefield obscurants like smoke. This concept was extended to take pictures of submerged mine fields in ocean water for the U.S. Marines. The Marines used the technology to identify safe landing areas. The military also used the cameras to "punch" through smoke to take pictures of Army vehicles hidden by smoke screens — vehicles not seen by the naked eye or other cameras.

Currently the technology is being studied for potential applications like imaging for aircraft guidance and control, developing 3-D images of landing areas especially in bad weather such as fog. Another potential use would be fast framing using X-rays or protons for internal combustion engine diagnostics. Short exposure medical X-rays are a possibility using this technology for restricting X-ray doses and dynamic radiog-

WEAPONS LABORATORY SCIENTISTS RESPONDED TO THE ON-AGAIN, OFF-AGAIN TESTING RIGORS

In October 1958, President Dwight Eisenhower declared a moratorium and stopped all testing. The Soviets stopped their tests in November of 1958, but soon resumed testing with a series of 50 detonations. Testing at Nevada resumed in September of 1961 with nine tests. Sixty-two tests were conducted the following year. In 1963, the Limited Test Ban Treaty was signed in Moscow, prohibiting testing in outer space, underwater or in the atmosphere. Testing went underground.

In 1974, President Richard Nixon signed the Threshold Test Ban Treaty that limited all nuclear test yields to less than 150 kilotons, but the treaty was not ratified until 1990.

In 1992 President George Bush signed a nine-month nuclear test moratorium which lasted until July 1, 1993. On July 3, 1993, President Bill Clinton pledged to extend the moratorium on nuclear weapons testing "as long as no other nation tests."

raphy such as analyzing knee-joint motion.

The other possible application of the technology is the development of hyper-velocity imaging such as monitoring or imaging destructive behavior or failure of tank armors as it happens. The only pictures available have been a before and after picture that tells researchers and designers little about the mechanics of the failure.

The Laboratory's radiochemistry techniques were advanced by nuclear testing, which has benefited the rest of the world. Radiochemical diagnosis was a technique used to determine the performance of nuclear weapons tests by analyzing the isotopes that remained in the bore hole. It was the prime basis for energy yield quotations. Researchers performed the analysis on all Los Alamos tests since the first nuclear explosion in 1945. Modern radiochemistry employs a variety of complex chemical and analytical techniques and is now used in a wide range of applications such as geophysics studies and ancient climate research.

Many of today's technologies were driven by test site science. Now many devices are only distantly related to the ones used in Nevada many years ago. For example, recording devices such as high-speed oscilloscopes and digitizers, which now are more technically complex, were spin-offs of devices used at the test site.

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